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Ryegrass or Alfalfa Silage as the Dietary Forage for Lactating Dairy Cows[1]

G. A. Broderick,* R. G. Koegel,* R. P. Walgenbach,* and T. J. Kraus†
*Agricultural Research Service, USDA
US Dairy Forage Research Center
1925 Linden Drive West, Madison 53706,
†Deere and Co., Ottumwa, IA 52501

ABSTRACT

Renewed interest exists in using grass forages to dilute the higher crude protein (CP) and lower digestible fiber present in legumes fed to lactating dairy cows. A 3×3 Latin square feeding study with 4-wk periods was conducted with 24 Holstein cows to compare ryegrass silage, either untreated control or macerated (intensively conditioned) before ensiling, with alfalfa silage as the sole dietary forage. Ryegrass silages averaged [dry matter (DM) basis] 18.4% CP, 50% neutral detergent fiber (NDF), and 10% indigestible acid detergent fiber (ADF) (control) and 16.6% CP, 51% NDF, and 12% indigestible ADF (macerated). Alfalfa silage was higher in CP (21.6%) and lower in NDF (44%) but higher in indigestible ADF (26%). A lower proportion of the total N in macerated ryegrass silage was present as nonprotein N than in control ryegrass and alfalfa silages. Diets were formulated to contain 41% DM from either ryegrass silage, or 51% DM from alfalfa silage, plus high moisture corn, and protein concentrates. Diets averaged 17.5% CP and 28 to 29% NDF. The shortfall in CP on ryegrass was made up by feeding 7.6% more soybean meal. Intake and milk yields were similar on control and macerated ryegrass; however, DM intake was 8.3 kg/d greater on the alfalfa diet. Moreover, feeding the alfalfa diet increased BW gain (0.48 kg/d) and yield of milk (6.1 kg/d), FCM (6.8 kg/d), fat (0.26 kg/d), protein (0.25 kg/d), lactose (0.35 kg/d), and SNF (0.65 kg/d) versus the mean of the two ryegrass diets. Both DM efficiency (milk/DM intake) and N efficiency (milk-N/N-intake) were 27% greater, and apparent digestibility was 16% greater for DM and 53% greater for NDF and ADF, on the ryegrass diets. However, apparent digestibility of digestible ADF was greater on alfalfa (96%) than on ryegrass (average = 91%). Also, dietary energy content (estimated as net energy of lactation required for maintenance, milk yield, and weight gain) per unit of digested DM was similar for all three diets. Results of this trial indicated that, relative to ryegrass silage, feeding alfalfa silage stimulated much greater feed intake, which supported greater milk production.
(**Key words:** ryegrass silage, alfalfa silage)

Abbreviation key: AS = alfalfa silage, **CRGS** = control ryegrass silage, **MRGS** = macerated ryegrass silage.

INTRODUCTION

Feeding alfalfa silage as the sole forage for ruminants often results in diets with excessive CP that is poorly utilized. Among the strategies that have been applied to dilute alfalfa CP have been to partially replace dietary alfalfa with corn silage for lactating cows (Dhiman and Satter, 1997) and to use interseeding of perennial ryegrass or orchardgrass with alfalfa for grazing cattle (Jung et al., 1982). Cool-season grasses such as perennial ryegrass are used widely for feeding to dairy cows; these grasses generally are higher in NDF and ADF than alfalfa (Cherney et al., 1990). Perennial ryegrass was reported to have substantially lower proportions of indigestible DM and NDF than alfalfa but to have rates of in situ digestion of DM and NDF that also were lower (Hoffman et al., 1993). This suggested that ryegrass may be amenable to treatment such as maceration that could improve fiber digestibility (Koegel et al., 1992). Improving digestibility of dietary forage would reduce the amount of dietary concentrate needed to maintain milk yield and would reduce fecal DM excretion. In previous research, we found that macerating alfalfa at the time of mowing improved its NE_L content by about 5%, mainly by increasing apparent digestibility of both NDF and ADF (Broderick et al., 1999). Canadian workers have found that maceration of timothy forage improved ruminal DM digestibility in cannulated steers (Chiquette et al., 1994); however, feeding this macerated timothy hay did not improve intake,

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Corresponding author: G. A. Broderick; e-mail: glenb@dfrc.wisc.edu.
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weight gain, or feed efficiency of growing lambs (Petit et al., 1997).

A lactation trial was conducted to compare the milk production of cows fed diets containing equal DM from either unmacerated or macerated perennial ryegrass silage; a positive control diet with alfalfa silage as the sole forage source and formulated to equal NDF also was fed. The objectives of the trial were to determine if maceration improved the nutritional value of ryegrass silage and to assess whether perennial ryegrass could serve as an effective, lower CP forage source for lactating dairy cows.

MATERIALS AND METHODS

Forage Harvest and Composition

A field of tetraploid perennial ryegrass (cv. 'Aubisque', Olds Seed Co., Madison, WI) was planted on April 15, 1998, after application of dairy manure at a rate of approximately 84 kg of N/ha; an additional 84 kg of N/ha was applied as NH_4NO_3 after second cutting on August 10, 1998. Fertilization with P and K was unnecessary because soil tests indicated levels recommended for ryegrass were exceeded. Alternate swaths were cut October 9, 1998 (third cutting), using either a conventional mower conditioner (control) or a prototype intensive conditioner (macerated; Broderick et al., 1999). Several fields were seeded in 1995 and 1996 with three different alfalfa cultivars (cv. 'Legendairy 2.0', Coop Country Partners, Prairie du Sac, WI; cv. 'WL322HQ' and cv. 'ICI620', Danco Prairie FS, Marksville, WI); soil tests also indicated that levels of P and K recommended for alfalfa were exceeded. First cutting alfalfa was cut using a conventional mower conditioner when alfalfa was at "mid-bud" to "late-bud" stage; 72% of the acreage was cut on May 18 to 21, 1998, and 28% was cut on May 24 to 25, 1998. All forages were field wilted to approximately 35% DM; target DM content was reached in 1 d after cutting for macerated ryegrass and in 2 d after cutting for both control ryegrass and alfalfa. The control ryegrass silage (**CRGS**) and macerated ryegrass silage (**MRGS**) were chopped to a theoretical length of 2.9 cm and ensiled in plastic bags (Ag-Bag International Ltd., Warrenton, OR). During silo filling, grab samples were taken midway through unloading of each wagonload of ryegrass silage. Electrical conductivity index, a measure of plant cell rupture (Kraus et al., 1999), was determined on a portion of each sample of chopped ryegrass forage; the balance of the sample was stored frozen (–20°C) for later analysis. Neither ryegrass was rained on during harvest. The alfalfa silage (**AS**) also was chopped to a theoretical length of 2.9 cm and ensiled in a large bunker silo. During ensiling, loads of AS were layered into the bunker such that proportionate amounts of each alfalfa cultivar and maturity were taken daily as this silo was fed out. Electrical conductivity index was not determined on the AS.

Weekly composite samples were prepared for all three silages from daily 0.5-kg samples collected during feed-out throughout the lactation trial and stored at –20°C until analyzed. At the end of the trial, weekly composites were thawed, water extracts were prepared (Muck, 1987), and extract pH was measured. Extracts were analyzed for fermentation acids (Muck, 1990) and also deproteinized (Muck, 1987) and then analyzed for NH_3 (Broderick and Kang, 1980) and for NPN (Muck, 1987) using a combustion assay (Mitsubishi TN-05 Nitrogen Analyzer; Mitsubishi Chemical Corp., Tokyo). A single mean result was computed for each silage for each variable for each 4-wk period. Thawed weekly composites also were dried at 60°C (48 h), ground through a 1-mm screen (Wiley mill; Arthur H. Thomas, Philadelphia, PA) and composited by mixing equal amounts of DM to obtain samples corresponding to each 4-wk period. These samples then were analyzed for DM at 105°C, ash and OM (AOAC, 1980), total N by combustion assay (Leco 2000; Leco Instruments, Inc., St. Joseph, MI), and NDF and ADF using heat stable α-amylase and Na_2SO_3 (Hintz et al., 1995). Mean composition data for the silages are in Table 1.

Lactation Trial

Twenty-four multiparous Holstein cows (mean ± SD) of 557 ± 50 kg of BW, parity 2.7 ± 1.6, 74 ± 17 DIM, and 42 ± 6 kg/d of milk were blocked into eight groups by DIM. Cows within blocks were assigned randomly to treatments in eight 3×3 Latin squares. The three diets, fed in the Latin squares as TMR, differed mainly in forage source (Table 2). High moisture shelled corn that was rolled when removed from the silo to a geometric mean particle size of 2.0 mm (Broderick et al., 2001) was fed as the principal concentrate component. Equal amounts of roasted soybeans that had been heated to 146°C and "steeped" at this temperature for 30 min (Faldet and Satter, 1991) were fed in each diet. Ryegrass diets contained equal DM from CRGS or MRGS; diets were formulated to have equal NDF and, thus, the AS diet contained more silage DM. It also was intended that all diets be equal in CP; however, the MRGS silage was lower in CP than CRGS (Table 1), possibly because of greater leaf loss during field harvest (Broderick et al., 1999). The CRGS and AS diets were equalized in CP by feeding more soybean meal with CRGS; the same level of soybean meal was fed with MRGS, so that diet contained less CP (Table 2).

Table 1. Composition of control and macerated ryegrass silage (RGS) and alfalfa silage.

Component	Control RGS	Macerated RGS	Alfalfa silage	SE[1]	$P > F$[2]
DM, %	32.3	37.6	36.2	1.2	0.09
CP, % of DM	18.4[b]	16.6[b]	21.6[a]	0.6	0.03
Ash, % of DM	15.1[a]	14.8[a]	10.9[b]	0.7	0.03
NDF, % of DM	49.5[a]	51.2[a]	43.5[b]	0.8	<0.01
ADF, % of DM	29.2	30.7	34.7	1.0	0.07
Hemicellulose, % of DM	20.3[a]	20.5[a]	8.8[b]	0.3	<0.01
Indigestible ADF, % of DM	9.5[b]	11.8[b]	18.8[a]	0.8	<0.01
Silage extracts					
pH	4.59[ab]	4.51[b]	4.68[a]	0.06	0.03
NPN, % of total N	59.8[a]	52.4[b]	61.5[a]	1.0	<0.01
NH_3-N, % of total N	12.3[a]	9.7[b]	9.5[b]	0.6	0.02
Fermentation products, % of DM					
Lactate	5.93[a]	5.38[ab]	4.35[b]	0.40	<0.01
Acetate	0.89[b]	1.03[b]	2.75[a]	0.14	<0.01
Propionate	0.44	0.18	Tr.[3]	. . .	. . .
Butyrate	1.53	1.38	0.46	0.30	0.07
Ethanol	Tr	Tr	Tr	. . .	. . .
Succinate	1.01[a]	0.69[b]	0.41[c]	0.05	<0.01
2,3-Butanediol	0.46[a]	0.32[b]	0.19[c]	0.02	<0.01

[a,b,c]Means in rows without common superscripts are different ($P < 0.05$).

[1]SE = Standard error.

[2]Probability of a significant difference due to silage source.

[3]Tr = Only trace amounts detected.

Diets were fed for three 4-wk periods (total of 12 wk). The first 2 wk of each period was allowed for adaptation to diet; a single individual mean from each cow for each production trait from the last 2 wk of each period was used in statistical analyses. Cows were milked twice daily and individual milk yields were recorded at each milking. Milk samples were collected at two consecutive (p.m. and a.m.) milkings midway through wk 3 and 4 of each period and analyzed for fat, protein, lactose, and SNF by infrared methods (AgSource, Verona, WI), and for milk urea N by a colorimetric assay (Ekinci and Broderick, 1997). Concentrations and yields of fat, protein, lactose, and SNF were calculated as the weighted means from p.m. and a.m. milk yields on each test day. Yield of 3.5% FCM also was computed (Sklan et al., 1992). Efficiency of conversion of feed DM was

Table 2. Composition of silages and diets fed during lactation trial.

	A	B	C
Item	Control RGS	Macerated RGS	Alfalfa silage
	(% of DM)		
Dietary ingredients			
Control ryegrass silage	40.6	. . .	. . .
Macerated ryegrass silage	. . .	40.6	. . .
Control alfalfa silage	. . .	. . .	51.2
Rolled high moisture shelled corn	44.7	44.7	41.5
Soybean meal	8.8	8.8	1.2
Roasted soybeans	5.4	5.4	5.3
Dicalcium phosphate	0.1	0.1	0.4
Salt	0.3	0.3	0.3
Vitamin-mineral concentrate[1]	0.1	0.1	0.1
Dietary composition			
CP	17.8	17.0	17.9
OM	90.8	90.2	92.4
NDF	27.7	29.2	27.8
ADF	14.8	15.6	19.3
Indigestible ADF	4.3	5.1	10.1
Phosphorus[2]	0.40	0.40	0.40

[1]Provided (per kg of DM): Zn, 56 mg; Mn, 46 mg; Fe, 22 mg; Cu, 12 mg; I, 0.9 mg; Co, 0.4 mg; Se, 0.3 mg; vitamin A, 6440 IU; vitamin D, 2000 IU; and vitamin E, 16 IU.

[2]Computed from NRC tables.

computed for each cow over the last 2 wk of each period by dividing mean milk yield by mean DMI; efficiency of utilization of feed N similarly was computed for each cow by dividing mean milk N output (total milk protein/6.38) by mean N intake. Body weights were measured on 3 consecutive days at the start and end of each period to determine BW change.

All cows were injected with bST (500 mg/d of Posilac; Monsanto, St. Louis, MO) beginning on d 1 of the trial, and then injected at 14-d intervals throughout. Cows were housed in tie stalls and had free access to water throughout the trial. The TMR were offered once daily at about 1000 h; orts were collected and recorded once daily at about 0900 h. The feeding rate was adjusted daily to yield orts of about 5 to 10% of intake. Weekly composites of each TMR, orts, CRGS, MRGS, AS, and high moisture shelled corn were collected from daily samples of about 0.5 kg and stored at –20°C. Weekly samples of soybean meal and roasted soybeans were stored at 21 to 24°C. Proportions of each ration ingredient on an as-fed basis were adjusted weekly based on DM determined by drying weekly composites at 60°C (48 h) for AS, RCS, and HMEC and at 105°C (AOAC, 1980) for soybean meal and roasted soybeans. Intake of DM was computed based on the 60°C DM determinations for TMR and orts. After drying, ingredients and TMR were ground through a 1-mm screen (Wiley mill). Period composites of the major diet ingredients and TMR were prepared by mixing equal amounts of DM from weekly composites.

On d 28 of each period, two fecal grab samples were collected from each cow at about 8 and 20 h after feeding; fecal samples were dried in a forced draft oven (60°C; 72 h), then ground through a 1-mm screen (Wiley mill). Equal DM from each fecal subsample was mixed to obtain a single composite for each cow during each period. Period fecal and TMR composites were analyzed as described earlier for DM, ash, OM, NDF, ADF, and total N, and for indigestible ADF (Huhtanen et al., 1994). Indigestible ADF (ADF remaining after 12-d ruminal in situ incubations) was determined by incubating 0.350-g samples of fecal and TMR composites in 5 × 10 cm Dacron bags with 50-micron pores (no. R510; Ankom Technology, Fairport, NY) in the rumens of two cannulated dairy cows fed a 60% forage, 40% concentrate diet (Luchini et al., 1996). Indigestible ADF was used as an internal marker to estimate apparent digestibility of nutrients (Cochran et al., 1986). Digestible ADF (100 – % indigestible ADF) also was determined on period composites of the three silages.

Statistical Analysis

Statistical analyses were done using the general linear models procedure of SAS (1989) with significance declared at $P \leq 0.05$. Analyses of silage composition were conducted using a model that included silage source and period. Where significant effects of silage source were detected, mean separation was conducted by least significant difference at a = 5%. Results from the lactation trial were analyzed as a 3 × 3 Latin square, replicated eight times, using a model that included diet, square, cow within square, period, and period × diet interaction; cow within square was used as the error term in testing for significant effects due to diet, period × diet interactions, and orthogonal contrasts. No period × diet interaction was significant for any variable ($P \geq 0.29$). Orthogonal contrasts were used to compare: 1) CRGS versus MRGS, and 2) CRGS and MRGS versus AS.

RESULTS AND DISCUSSION

Forage Composition

The two perennial ryegrass silages were similar in ash, NDF, and ADF; however, MRGS contained less CP ($P < 0.05$) and was numerically higher in indigestible ADF than CRGS (Table 1). This may have been due to greater leaf loss during field harvest of the MRGS. Previously, we found that alfalfa silage macerated with the same prototype machine as was used here for MRGS contained, respectively, 1.2 and 1.6 percentage units more ash and NDF than control alfalfa silage (Broderick et al., 1999); this suggested that there was greater leaf-loss and soil contamination during field-pickup and chopping of the macerated forage using a conventional forage harvester. However, Petit et al. (1997) detected no differences in the composition of control timothy hay and timothy hay macerated using a different prototype of intensive conditioner. As expected, AS contained more CP, less ash and NDF, similar ADF, less hemicellulose, and much more indigestible ADF compared with the ryegrass silages (Table 1).

Composition of aqueous silage extracts, notably the normal pH values and normal levels of NH_3-N, and absence of detectable amounts of ethanol (Kung and Shaver, 2000), suggested that the three silages were of good quality (Table 1). Concentrations of lactate were higher and acetate lower in ryegrass silages than AS, but levels of both acids were typical for grass and legume silages with about 35% DM (Kung and Shaver, 2000). Butyrate concentrations averaged, respectively, 1.5 and 0.5% of the DM in the ryegrass silages and AS and were quite variable, ranging from 0 to 3.8% among samples of the three silages. This variation prevented the large difference between AS and the ryegrass silages from being judged statistically significant. Butyrate levels >1% of DM in grass silage normally are indicative of clostridial fermentations; however, lactate

Table 3. Performance of lactating cows fed diets containing forage harvested as either control ryegrass silage (CRGS), macerated ryegrass silage (MRGS), or control alfalfa silage (AS).

	Dietary forage				Contrasts[2]		
Variable	CRGS	MRGS	AS	SE[1]	$P > F^2$	CRGS vs. MRGS	AS vs. RGS
DMI, kg/d	16.8	17.0	25.2	0.5	<0.01	0.85	<0.01
BW gain, kg/d	0.43	0.47	0.93	0.10	0.01	0.80	<0.01
Milk, kg/d	35.6	34.5	41.1	0.5	0.06	0.74	0.04
Milk yield/DMI	2.15	2.06	1.65	0.04	0.01	0.53	<0.01
Milk-N/N-Intake	0.372	0.378	0.295	0.009	0.01	0.81	<0.01
3.5% FCM, kg/d	31.3	31.2	38.0	0.8	0.04	0.97	0.01
Fat, %	2.80	2.94	3.08	0.09	0.39	0.52	0.23
Fat, kg/d	0.98	1.00	1.25	0.04	0.03	0.86	<0.01
Protein, %	3.16	3.18	3.31	0.05	0.06	0.71	0.02
Protein, kg/d	1.11	1.09	1.35	0.03	0.01	0.77	<0.01
Lactose, %	4.76	4.75	4.93	0.03	0.03	0.91	<0.01
Lactose, kg/d	1.68	1.64	2.01	0.03	0.04	0.74	0.01
SNF, %	8.72	8.73	9.06	0.07	0.02	0.90	<0.01
SNF, kg/d	3.08	3.00	3.69	0.05	0.03	0.74	<0.01
MUN, mg/dl	10.5	9.5	14.1	0.2	<0.01	0.05	<0.01

[1]SE = Standard error.

[2]Probability of a significant effects of diet and orthogonal contrasts [error = cow(square)].

averaged 68% of total silage acids, suggesting that the ryegrass fermentations may not have been unsatisfactory (Kung and Shaver, 2000). Lower NPN and NH_3-N in MRGS than CRGS indicated that pH drop was sufficiently more rapid, resulting in less protein being degraded in the macerated forage. Previously, maceration was found to lower both pH and NPN content of AS (Broderick et al., 1999), to reduce proteolysis during conservation of alfalfa and timothy herbage (Agbossamey et al., 1998), and to increase lactic acid in macerated orchardgrass-white clover silage (Charmley et al., 1999). Reducing silage NPN will improve utilization of CP in lactating dairy cows (Nagel and Broderick, 1992; Makoni et al., 1997).

Lactation Trial

Animal production data are summarized in Table 3. Overall, there were no differences ($P \geq 0.52$) in DMI, BW gain, milk yield, feed efficiency (milk yield/DMI) and N efficiency (milk-N/N-intake), milk composition, and yield of milk components between feeding of CRGS and MRGS. Previously, we observed that macerating alfalfa silage improved milk production and feed efficiency by about 5% (Broderick et al., 1999). The electrical conductivity index of leachate extracts from forages is an indicator of the extent of cell damage (Kraus et al., 1999). In the present study, there was an increase of about 10 percentage units (from 10 to 20%) in the electrical conductivity index for MRGS versus CRGS (data not shown). While this represents a degree of conditioning greater than that with the conventional mower-conditioner, it was much smaller than was obtained previously when alfalfa was macerated using the same prototype machine. In those trials, the electrical conductivity index of macerated alfalfa was about 60% versus about 10% for conventionally conditioned alfalfa (Kraus et al., 1999).

Substantially greater DMI on AS supported BW gain, yields of milk, FCM, fat, protein, lactose, and SNF, and milk content of protein, lactose, and SNF that all were greater ($P \leq 0.04$) than on ryegrass silage. The only exceptions to these trends were the substantially lower ($P < 0.01$) milk yield/DMI and milk-N/N-intake on AS; however, the greater BW gain found with feeding of AS, and the presumably greater energy- and N-retention that would have resulted, were not considered in these computations. Lower concentrations of milk urea on ryegrass than on AS, and on MRGS than on CRGS, probably reflected differences in CP intake among diets (Broderick and Clayton, 1997).

Differences in DM and N efficiency between the ryegrass and AS diets were associated with large, significant effects ($P < 0.01$) of silage source on apparent nutrient digestibility (estimated using indigestible ADF as internal marker; Table 4). Apparent digestibility of DM, OM, NDF, ADF, and CP all were higher, and fecal DM output lower, on ryegrass than on AS. The only difference detected between the ryegrasses was lower ($P = 0.02$) apparent digestibility of ADF on the MRGS diet; this effect probably was confounded by what appeared to be greater leaf losses during field harvest of this forage (Table 1). However, the overall results indicated that the small increase in cell rupture achieved with the prototype macerater in this trial did not improve utilization of the nutrients in ryegrass silage.

Table 4. Effect of feeding control ryegrass silage (CRGS), macerated ryegrass silage (MRGS), or alfalfa silage (AS) on apparent digestibility and utilization of dietary nutrients.

	Dietary forage				Contrasts[2]		
Variable	CRGS	MRGS	AS	SE[1]	$P > F$[2]	CRGS vs. MRGS	AS vs. RGS
Apparent digestibility							
DM, %	77.7	76.4	66.8	0.8	<0.01	0.34	<0.01
OM, %	79.4	78.7	69.0	0.7	<0.01	0.60	<0.01
NDF, %	66.2	63.5	43.6	0.9	<0.01	0.15	<0.01
ADF, %	64.7	60.4	42.6	0.9	<0.01	0.02	<0.01
Digestible ADF, %	91.4	90.9	96.1	1.1	0.04	0.81	0.01
CP, %	71.8	69.8	60.3	1.3	<0.01	0.34	<0.01
Fecal DM, kg/d	3.74	4.03	8.40	0.23	<0.01	0.57	<0.01
Net energy computations							
Required,[3] Mcal/d	33.9	33.9	41.6	. . .	. . .	. . .	. . .
DDM Intake,[4] kg/d	13.0	13.0	16.8	. . .	. . .	. . .	. . .
NE_L/DDM, Mcal/kg	2.60	2.61	2.47	. . .	. . .	. . .	. . .
Relative NE_L/DDM[5]	1.05	1.05	1.00	. . .	. . .	. . .	. . .

[1]SE = Standard error.

[2]Probability of a significant effects of diet and orthogonal contrasts [error = cow(square)].

[3]Requirements for NE_L for maintenance (582 kg mean BW), BW gain and milk yield (Table 3), computed using NRC (2001) tables.

[4]Intake of digestible DM computed from mean DM intake (Table 3) and mean apparent DM digestibility.

[5]Setting the value obtained on the alfalfa silage diet equal to 1.00.

A striking finding in our trial was that DMI averaged 8 kg/d greater on the diet containing AS than on those with perennial ryegrass. Elevated butyrate concentrations, as were seen in both ryegrass silages (Table 1), may reflect clostridial fermentations that can result in depressed DMI (McDonald et al., 1991). However, as discussed earlier, chemical composition data other than butyrate suggested that these were typical of grass silages. The addition of up to 5.4% butyric acid in silage DM did not itself depress DMI in sheep (Buchanan-Smith, 1990). Steen et al. (1998) reported data from a large number of silages, indicating that DMI in cattle was only poorly correlated to butyrate concentration ($R^2 \leq 0.11$). Moreover, McDonald et al. (1991) cited data showing that, in grass silages harvested with from 19 (direct-cut) to 43% DM and containing 1.1 to 3.0% butyrate, DMI was maximal in steers fed silage with 32% DM and 2.7% butyrate. Ryegrass silages averaged 35% DM and 1.5% butyrate in the present experiment. Intake depression due to clostridial fermentation likely does not explain the low DMI on the ryegrass silages.

Greater feed intake on legumes than cool-season grasses has been a common finding of ruminant feeding studies. Hoffman et al. (1998) observed greater DMI and yield of milk and protein on diets containing AS rather than perennial ryegrass silage, but their differences were not of as great a magnitude as in our trial. Comparing formic-formaldehyde treated forages, Thomson et al. (1991) found that greater DMI in steers fed late-cut alfalfa silage produced greater BW gain than feeding orchardgrass silage cut 2-wk earlier because greater intake compensated for lower digestibility of alfalfa. Wilkins and Jones (2000) summarized results, indicating silage DMI by lactating cows increased from 11.1 kg/d on perennial ryegrass to 13.6 kg/d on alfalfa—23% greater intake of AS. Using feed characteristics tabulated by Rotz et al. (1999), "fill unit" values for our ryegrass and the AS diets would be, respectively, 28.6 and 24.5% of DM. If other factors such as ruminal fill were equal, the model of Rotz et al. (1999) predicted a relative DMI of 21.6 kg/d on the ryegrass diets would correspond to a DMI of 25.2 kg/d on AS. In dairy cows grazing perennial ryegrass swards with regrowth ranging from 6 to 30 d in age, Chilibroste et al. (2000) observed mean ruminal NDF fills ranging from 0.4 to 0.8% of BW—all substantially less than the ruminal limit of 1.0 to 1.3% of BW reported by Mertens (1994) and predicted by Rotz et al. (1999) for wk 4 to 45 of lactation. This suggested that factors other than ruminal fill limited ryegrass intake in that grazing study (Chilibroste et al., 2000) as well as in the present trial. Ruminal fill was not measured in our experiment.

More rapid fiber and particle breakdown in the rumen likely were factors in the greater DMI on AS. Hoffman et al. (1998) found that, when DMI was 11% greater on alfalfa than on ryegrass silage, passage rate of chromium-mordanted fiber through the total tract was 20% more rapid. In our experiment, apparent digestibility of ADF averaged 63% for ryegrass versus 43% for alfalfa; however, apparent digestibility of the digestible fraction of ADF actually was greater on alfalfa than on ryegrass (Table 4). This indicated that microbial attack of digestible alfalfa fiber proceeded more rapidly in the rumen despite higher intakes and presumably greater rates of passage. Hoffman et al. (1993) observed substantially different DM digestion curves when these forages when incubated in the rumen in situ: Perennial ryegrass had slower rates, but greater extents of digestion, than alfalfa. Extents of DM digestion were computed to be 69 and 60% for, respectively, ryegrass and alfalfa with similar CP and NDF contents as the silages fed in the present trial (Hoffman et al., 1993). Excretion of metabolic fecal N is directly related to DMI (NRC, 2001); the reduction in apparent digestibility of CP on AS likely resulted from large increases in metabolic fecal N associated with the 8.3 kg/d greater DMI on AS (Table 3).

The NE_L requirements for maintenance and observed BW gain and milk production were computed (NRC, 2001); these estimates are in Table 4. Expressing NE_L requirements per unit of digestible DM consumed yielded values for the CRGS and MRGS diets that were only about 5% greater than for containing AS. This small difference may be explained by that portion of the heat increment of feeding attributable to the greater digesta load (Webster, 1980) when cows were consuming the AS diet. The similarity of this result was surprising in view of the average 27% greater milk yield/DMI observed on the diets containing ryegrass silage (Table 3). This finding confirmed that the differences in animal production and efficiency between the two forage sources could be explained by differences in intake and digestibility and were not due any differences in nutrient metabolism.

SUMMARY AND CONCLUSIONS

A Latin square feeding study conducted with lactating Holstein cows indicated that there were no production differences between feeding control and macerated perennial ryegrass silage. However, DMI was 8 kg/d greater when cows were fed AS rather than either ryegrass silage. The greater DMI was associated with greater BW gain and greater yields of milk, FCM, fat, protein, lactose, and SNF with feeding of alfalfa silage. Efficiency of utilization of dietary DM (milk/DMI) and N (milk-N/N-intake), and apparent digestibility of DM, OM, NDF, and ADF, all were greater on the ryegrass diets. However, apparent digestibility of digestible ADF was greater on alfalfa than on ryegrass; dietary NE_L per unit of digested DM was similar for all three diets. Results of this trial indicated that, relative to ryegrass silage, feeding alfalfa silage stimulated much greater feed intake, which supported greater milk production.

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